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COMMUNITY WATER SYSTEMS IN THE UNITED STATES, THEIR PROTECTION AND THEIR IMPACT UPON HEALTH

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COMMUNITY WATER SYSTEMS IN THE UNITED STATES
(Their Protection and Their Impact Upon Health)

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1. A community water system, for the purposes of this discussion, is defined as the integrated delivery of a safe water, in ample quantity, into the individual household of every member of the community. It is implied that the provision of this amenity for potable, domestic, and industrial purposes is on an uninterrupted basis twenty-four hours a day, and 365 days a year. Full pressures on the water mains are likewise presupposed, under the sustained full-time management of a responsible local agency.

2. These detailed specifications are spelled out to distinguish real community systems from those intermittent water services, of sometimes safe quality, delivered at points remote from the user and at pressures often reduced to zero. Even these latter inadequate services are now only sparingly available to somewhat more than two-thirds of the population of the world. In retrospect, however, they represent a reasonable picture of the domestic water supply situation in the United States some 100 years ago. It is valuable, therefore, to retrace the history of community water development in this country, in order to determine the means by which this gap has been largely closed and to measure the impact which this development has had upon the public health and upon society in general. Not always were the people afforded this universal necessity and luxury for safeguarding life and cleanliness. Some of the lessons of the past, therefore, have important implications for accelerating the installation of water facilities throughout the globe.

The History of Community Water Expansion in the U.S.

3. The earliest public water supplies date from 1652 at Boston, about 1732 at Schaefferstown, Pa., and at Bethlehem, Pa., in 1761. At the close of 1800, only 17 water works were in operation. The number did not pass the hundred mark until 1850 and the thousand mark until 1885. By 1895, the figure had reached about 3000. At the close of 1924, it is estimated that over 9,000 water works were supplying about 10,000 communities.

4. The turn of the faucet was by then all that was necessary for thousands of people to secure either hot or cold water on any floor of a dwelling. The public water supply was already having its impact upon public health, the protection of life and property against fire, street sprinkling, sewer flushing and many industrial uses. These supplies were not only substituting safe for unsafe drinking water, but were also making water carriage sewerage systems possible, which in turn were abolishing the dangerous privy and cesspool.

5. The evolution of the systems under private sponsorship is of interest, particularly in view of the fact that, outside of the United States and much of the European areas, private ownership of community water systems is frowned upon and often prohibited. Yet in 1890, in the United States, of some 23,000,000 people supplied, about one-third was privately owned and operated. By 1925 over 85 percent of the people were provided by municipally-owned water works. Although this ratio had been materially altered by 1960, it is still true that approximately 20 percent of the people are served by privately owned systems. Private capital may have an honorable place in many countries in the development of new water systems, provided governmental policy and climate are favorable.

6. By 1900, about 30 million people had the advantages of a municipal water supply, with a use of some 3 billion gallons a day. In 1954, these figures had grown to over 100 million people, with a daily total use of some 16 billion gallons. The average use per person per day, for the country as a whole, was approximately 150 gallons.

7. Today, some 21,000 communities, serviced by some 18,000 systems, provide approximately 135,000,000 people with water facilities as earlier defined.

8. The continuing rapid urbanization and industrialization of the United States gives no basis for assuming that the provision of new water facilities is at an end or, in fact, may even be tapering off. On the contrary, all projections for the future show major increases in population and continued marches toward the urban areas. It is probable, therefore, that total demands by 1980 will reach at least 29 billion and by 2000 at least 43 billion gallons per day. Even the per capita daily uses will rise with the increase of the standard of living, and the wider use of water requiring household equipment, such as the automatic clothes washers.

The Cost of Facilities

9. Because of the long history of community water development in the United States no truly reliable estimate is available of the total investment in these facilities. It may be assumed, however, that it exceeds, for the complete systems, some 17,000,000,000 dollars. In the year 1958 alone, the capital expenditures reached almost 850,000,000 dollars.

10. Of much greater significance than these astronomical figures is the transcendent fact that unit costs or per capita annual costs are surprisingly and modestly low. This salient fact needs to be emphasized and re-emphasized in applying the lessons of United States experience to the solution of this important problem in developing countries. In these regions, the staggering capital investments required frighten the ministers of finance, of public health and of public works. Yet, the strengthening of borrowing power, the development of the principle of reimbursability, the fortifying of local responsibility in management and fiscal control, all change the emphasis in time from capital investment figures to annual costs per person. These latter amounts are not intimidating and are increasingly within the grasp of millions of people, when the realities of sound financing appear on the horizon.

11. The case history of the United States is again full of confirmation of these generalizations. For example, in 1954, the latest year for verifiable data, the average annual cost for water per person was $9.79, with a high in the arid Great Basin region of $13.67 and a low in the humid Chesapeake Bay region of only $7.97. Even with the great developments for community water projected for 1980 and 2000, involving billions of dollars of capital expenditure, the annual costs will remain $10 or less per person, on the average. These annual costs include operation, maintenance, interest and amortization.

12. Safe water delivered into the house is a remarkably cheap and plentiful commodity. It generally costs from 5 and 10 cents a ton. No limit should be placed on the amount furnished or the time at which it is available, provided it is not wasted or dissipated uselessly and the customer pays for it.

13. In general, these criteria have been the guiding ones in this country and increasingly they are being more fully met. Of equal importance, however, is the realization that this amenity has been universalized among urban dwellers almost entirely through local responsibility and local financing and repayment. So successful has this performance been for over 100 years, that water works bonds are rated among the highest priorities of safety in the open financial market. Defaults have been rare, interest rates often are less than 6% and frequently less than 4% annually, and periods of repayment in general extend to as much as 40 years.

14. These situations are evolutionary. They have not always been so. They reflect at least half a century of local responsibility and integrity, and a climate of political stability. Without them, public water systems will be slow in creation and non-generative in character. Central government subsidy, external largesse, in any form of gift rarely provide the above necessary ingredients. The major lesson of the United States experience is that the present 18,000 systems are predominantly the result of local financing, without any significant central government subsidy.

The Search for Pure Water

15. Man has pursued the quest for "pure" water for thousands of years. The criteria for purity have become during these centuries, more complex, more quantitative and increasingly more rigid. The search, of course, is never ending, because the world is not static, technology is ever on the move, populations and their consequent waste products eternally increase and because the consumer protection requires more and more complex controls.

16. The disease hazards of water, although empirically suspected in earlier years, were not the major motivations toward community systems. The chemical test long preceded the great progress of control in the biological era. To these have now been added the diagnostic indices for more exotic organic and inorganic substances in water, whose physiological effects are still but dimly understood. Accompanying all of these throughout the last century has been the ever-increasing demand by the consumer, often running ahead of the technologist, for esthetic perfections of superior palatability.

17. These advances in desire were naturally initiated by the forward march of water purification methods, closely followed by sewage treatment processes to guard and improve the surface and ground water sources of the community systems. The great progress in these installations, it must be again remembered, was made only over the last century.

18. Until 1870 no water filtration plants existed in the United States. In the 1870's the Poughkeepsie and Hudson, N. Y. slow sand filters were built, followed by those at Lawrence, Mass. in 1893. In the late 80's the earliest rapid sand units appeared. By 1897 over 100 of such installations had been built, and by 1925 about 587 rapid and 47 slow sand filters were already in use. They were delivering approximately 5 billion gallons per day.

19. At the turn of the 20th century, the great additional jump forward in water protection came about in the introduction, in 1908, of the use of chlorine for bacterial disinfection. Chlorination subsequently became the universal beneficial "vade mecum" of the sanitarian, both in water and in sewage treatment.

20. Installations for water treatment have proceeded at a high rate from 1925 to date. Simultaneously, however, sources of water have become increasingly polluted by familiar biological and chemical materials, reinforced by newer and less familiar types of industrial and other wastes, such as synthetic organic chemicals and radioactive materials. Many viruses and other disease-producing organisms add to the ever-growing control problems.

21. In spite of the delays due to economic depressions and wars, progress in pollution abatement has been great in the last 40 years. By 1957, over 7500 sewage treatment plants had been serving some 77 million people. An additional 22 million had sewerage at that time, although their 3000 communities were discharging raw sewage. The sewered population covered somewhat less than 100 million people in over 11,000 communities.

22. The tabulation which follows places these accomplishments in chronological perspective: (in millions)

Year	Urban Population	Sewered Population
1900	30	25
1920	54	50
1940	80	70
1960	126	105
1980	200 (estimated)	200 (estimated)

23. The sewage pollution abatement picture, however, still remains less than satisfactory, even though United States cities spent more money in 1961, for this purpose, than ever before. On January 1, 1962, some 5290 communities still had inadequate or no sewage treatment facilities. Their impact on drinking water quality, however, should not be exaggerated since water treatment processes have been singularly effective. In addition, less than 4% of the 5290 communities encompassed more than 5000 people apiece.

24. The expenditures in 1961 for sewage treatment were approximately 560 million dollars. Federal funds were represented in this amount to the extent of $1 of Federal money to every $5.50 of local municipality money. In prior years, by far the largest expenditure had its origin locally, unsupported by central government subsidy. For the future, the projected annual costs (operation, maintenance and amortization of investment) for collection and treatment will be $818 million for 1980 and $1200 million for 2000. The projected annual costs per person are again extremely modest, namely, less than $5.00 in 1980 or 2000.

The Impact Upon Public Health

25. Impure water has always been a carrier of disease. Contamination of water courses, surface or underground, has been the rule wherever there were people. The wastes of man have invariably been indiscriminately distributed in his environment. Since man has been the host of many diseases and many of these have spent part of their life cycle in the digestive tract, their causative organisms have found their way into human urinary and fecal discharges. The number and variety of these organisms have been myriad. They run the gamut from the ubiquitous typhoid fevers, amebic dysenteries, infectious hepatitis, schistosomiasis, and others too long to enumerate.

26. All of these diseases, not too long ago, plagued this country. All are in part water-borne. Today, many of these diseases are relegated to the classification of "tropical." This designation, however, is truly a misnomer, since these so-called "tropical" diseases at one time were universally distributed, in cold as well as hot climates. They have not, in fact, disappeared from the Western

World, but have been banished and controlled by environmental sanitary measures, such as water purification. When these measures are relaxed, the diseases recur.

27. In most developing countries, many of which are tropical, these sanitary restraints have not yet come into play on any large scale. Until they do, the enteric diseases will continue to take a major toll in disability and in lives.

28. The major lesson of the advent of community water for all the people in the United States is in the great accompanying reduction in the enteric diseases of water-borne character. Typhoid fever disappearance is a striking example of this accomplishment. This experience gives equal promise to other evolving countries. A brief review of its history in this country is pertinent, because it represents one of the most remarkable public health achievements since the turn of the twentieth century.

29. The typhoid fever deaths per 100,000 in 1900 were 35.8. By 1936 it had been brought down to 2.5, while today it is virtually zero. (Figure I) Minor recrudescences occur, but it is rare to see a typhoid case in an American hospital. Of equal significance is the fact that in the large cities, say over 100,000, the rates have consistently been notably lower than those for the Nation as a whole. Safety of water, coupled with pasteurized milk, have undoubtedly accounted for this prideful accomplishment. It can and should be matched in the next decades in the developing countries.

30. The role of water quality in the dissemination of enteric diseases, of course, has been recognized for more than 100 years. That pathogens causing the diarrheal diseases of children, typhoid fever, cholera, and shigellosis can survive in water and can cause illness to those who ingest the water is well known. Because of its comparative universality, typhoid fever morbidity and mortality data have been used as criteria of water sanitation, despite the fact that water is not the only mode of transmission of that disease. The increase in the number of municipal water supplies has paralleled closely the decline in typhoid deaths for over half a century. Undoubtedly, continuous disinfection of public water supplies with chlorine accelerated this decrease of water-borne typhoid fever. A very considerable decrease of water-borne typhoid occurred, however, even before the disinfection with chlorine became a common practice. This would seem to indicate that the installation of community water supplies, even though not all of the highest sanitary quality, may be expected to have an appreciable effect on typhoid fever death rates.

31. The annual reports of the Massachusetts State Board of Health prior to 1900 yield considerable evidence on the value of public water supplies in reducing typhoid fever, even before chlorination was adopted. Very early the Massachusetts Department of Health recognized the relationship between community water supplies and typhoid fever incidence. That department was the first state health department in the United States of America. It early assumed an active role in the promotion of community water supplies and investigation of the effect of such water supplies on the public health. The growth of water supplies and the corresponding typhoid fever death rates in the State is shown in Figure II.

32. In the case of typhoid fever and cholera, the principle involvement of the water supply is in connection with water which is ingested through the mouth. In the case of shigellosis and some of the infant diarrheas, there is increasing reason to believe that the availability of water supply in ample quantities may be equally or even more important than the bacteriological quality of the supply. In a well controlled study, Hollister et al have reported on the influence of water availability on shigella prevalence in children of farm labor families in the state of California, USA. Their studies confirm the impression of Watt who had postulated that water, even though it might be "below standard," could act as a diluent

and assist in the reduction of intestinal infection when used for personal hygiene purposes. Hollister and his colleagues compared the shigella positivity rates between camps which had cabins equipped with inside water faucets and camps which had a portion or all of the cabins with outside water faucets. Their data are shown in Figure III.

33. Wagner and Lanoix comment on a study carried on in Palmares, state of Pernambuco, Brazil, by the Servicio Especial de Saude Publica. This Brazilian study showed that there probably was a relation between the availability of water supplies and the deaths from diarrhea of young infants. The study also gave some indication that the health risk was about the same whether the treated water was carried from public fountains to private houses or whether water was taken from open unprotected "wells."

34. The record of the impact of water supply upon disease in the United States gives no basis for assuming that control and eternal vigilance may be dispensed with, once water systems are provided. We have a long history of recurring water-borne disease when such vigilance has been relaxed. Unfortunately, the disappearing enteric diseases do lead to the impression that water-borne epidemics are no longer to be feared as they were in the past. Those who hold this viewpoint must take heed of the toll exacted by these diseases since 1920, even while the total picture has been amazingly good.

35. Perhaps one of the stimulating forces in the rapid development of purification lay in the attitude of the courts in the award of damages against private and public corporations found responsible for illness resulting from pollution of water supplies. In several instances the damages were high, as in the case of Olean, N. Y., where the city had to issue bonds to the extent of $350,000 to pay the costs incurred in a water-borne typhoid fever epidemic of 1929. An incomplete listing now accounts for such payments in somewhat over two dozen instances.

Global Implications

36. Recently, Dr. Abraham Horwitz, the Director of the Pan American Health Organization, speaking from his experience in his native Chile and from the results of his programs in North America, Central America, and South America, made the following statement:

> "If a single program were chosen which would have the maximum health benefits, which would rapidly stimulate social and economic development, and which would materially improve the standard of living of people, that program would be water supply with provision for running into or adjacent to the house."

37. Despite the deficiencies in the reporting of enteric diseases in many developing countries, it is clear in all of them that the mortality from typhoid fever, gastritis, enteritis, etc., is excessively high. It ranges in the figures prevailing in North America in the last period of the 19th century. As a matter of fact, for all age groups and particularly for infants and children 1-4 years of age, the diarrheal diseases rank either first or in the first five of the principal causes of disability and death.

38. As Dr. Horwitz points out, and as is generally accepted by most health officials, a major reduction in these diseases is possible, quite independent of etiologic and sociologic differences in countries or regions, by the provision of potable water in sufficient quantities to keep clean and conveniently accessible to people. In such programming, safe water for the thirsty is not the sole objective and greater quantities of water must be provided for all the other amenities of cleanliness and urban living.

39. The situations in two regions of the world may illustrate both the public health need and the deficiencies in community water service. In the Central and South Americas, the deaths from the enteric diseases are still higher, in some countries, than 200 per 100,000, and figures in excess of 100 per 100,000 are common. Of the 16 countries of Latin America, in the age group 1 to 4 years, diarrheal diseases were the leading cause of death in 11 and among the first five principal causes in the remaining five. These facts are graphically demonstrated in Figure IV.

40. Using water service as hitherto defined, the availability of water in the Americas is sadly deficient. Out of 75 million people in cities of more than 2000 population, 29 million are without such service. Almost 50 percent of the people in cities of 10,000 to 50,000 are in the same deficient category. More than 70 percent are without service in cities of 2,000 to 10,000. In rural areas, matters are even worse. Of these 107 million people, far more than 70 percent are without water service.

41. The leaders of these countries are of course well aware of these deficiencies and of the snail's pace in their correction. This understanding is well reflected in the Charter of Punta del Este which calls for the provision of adequate water supply, sewerage and excreta disposal, in the next ten years, for at least 70 percent of the urban and 50 percent of the rural population. To accomplish this sound purpose will require strong support for the prompt and continuing adoption of the fiscal, engineering and managerial principles which have resulted in the great progress in the United States.

42. In another part of the globe, India, similar disease and water deficiencies confront the policy maker. The issues are the same as previously discussed. They are well recognized. Impatience with the slow pace of community water development over the last 20 years drives this country toward the realization that a new look, at an old problem, is demanded.

43. Such a new look in India was completed in 1961 by a Special Committee created by the Ministry of Health, Government of India, by an order dated April 28, 1960. The inquiry resulted in conclusions and recommendations issued in 1962 by the Committee on National Water Supply and Sanitation. Its findings warrant brief restatement here in abbreviated form:

(a) For the urban population of 78,000,000, about 34 percent were judged as adequately served with water, 26 percent inadequately and 40 percent not served.

(b) For the same urban population, adequate sewerage service was available for 21 percent and no service for 68 percent.

(c) In the rural areas, defined by the Committee as encompassing some 300,000,000 people, progress on individual well installations aggregating over 500,000 in number is significant, but unsatisfactorily slow.

44. The closing of these sanitary gaps in India, it is recognized officially, will require "a new path to be cut if the program is to succeed and move on its own momentum. Local bodies should be encouraged to promote urban water supply and sewerage schemes as a self-paying industry, just as electricity undertakings are promoted and operated. The method of financing of such schemes should be patterned after the procedure and practice which have succeeded and established themselves in the more advanced countries, with such modifications as are dictated by conditions in this country."

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